Armed Forces College of Medicine

AFCM

Smooth muscles

By

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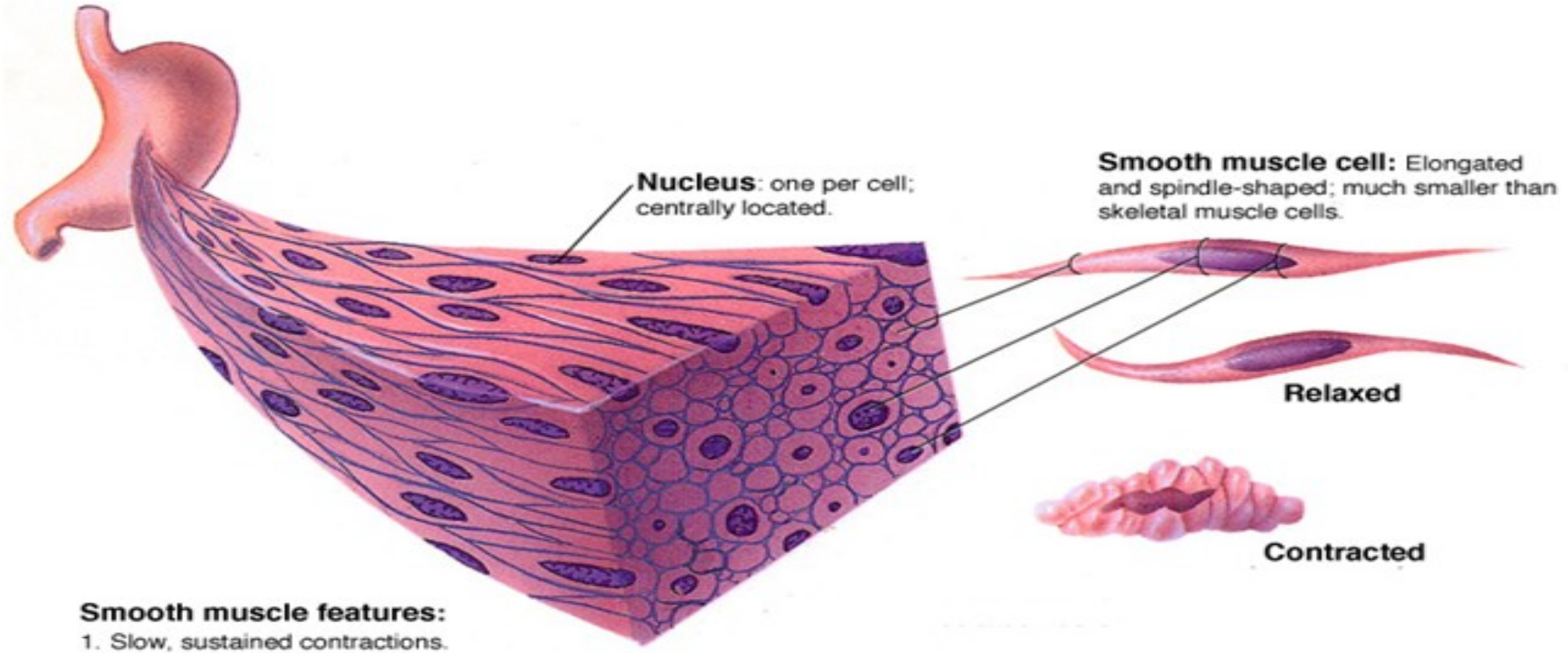
INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

- ✓ **Describe how calcium activation of myosin cross bridge in smooth muscle**
- ✓ **Compare the role of calcium in bringing about contraction in smooth muscle & skeletal muscle**
- ✓ **Describe the functional types of the smooth muscle**
- ✓ **Describe the smooth muscle action potential**
- ✓ **List the properties of smooth muscle contraction**

Functional Structure of Smooth Musc



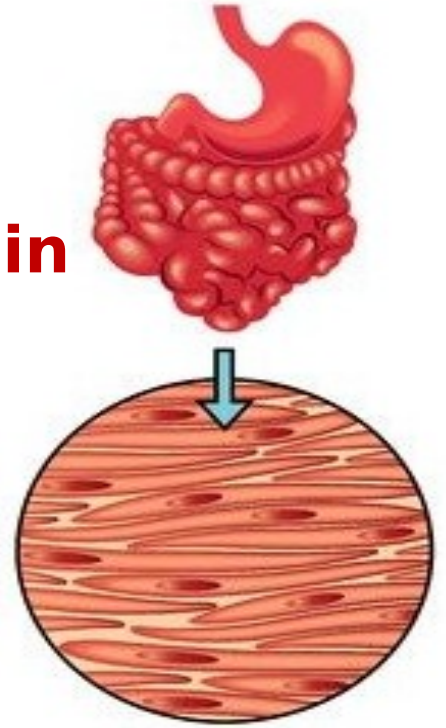
Smooth muscle features:

1. Slow, sustained contractions.
2. Under autonomous (non-voluntary) control.
3. Contain actin and myosin filaments but lack sarcomeres.
3. Prominent locations:
    1. Wall of GI tract.
    2. Walls of arteries and veins.
    3. Around glands.

Functional Structure of Smooth Musc

Main characteristics:

- **Contractile proteins: Actin & Myosin**
- **Regulatory proteins: Tropomyosin & Calmodulin**
- **NO striations**
- **NO Z- lines → Dense bodies**
- **NO T- tubules**
- **Poorly developed SR**
- **Few mitochondria**

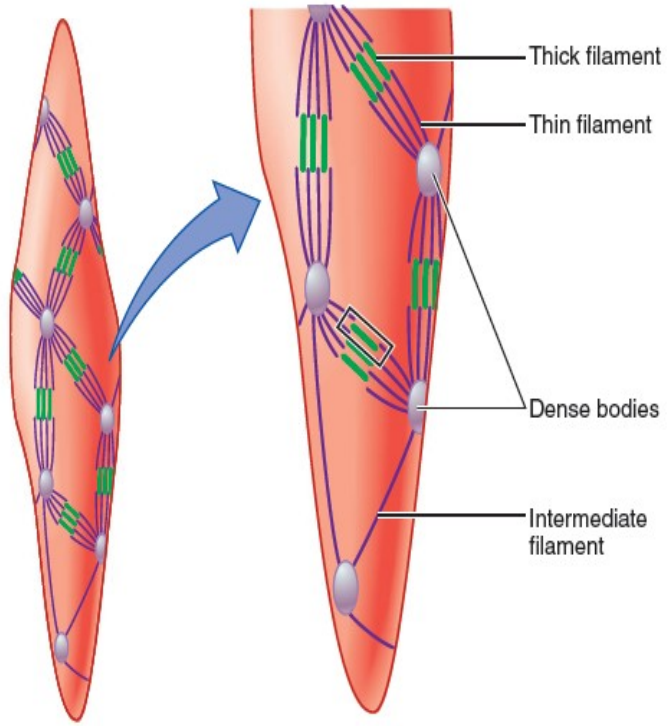


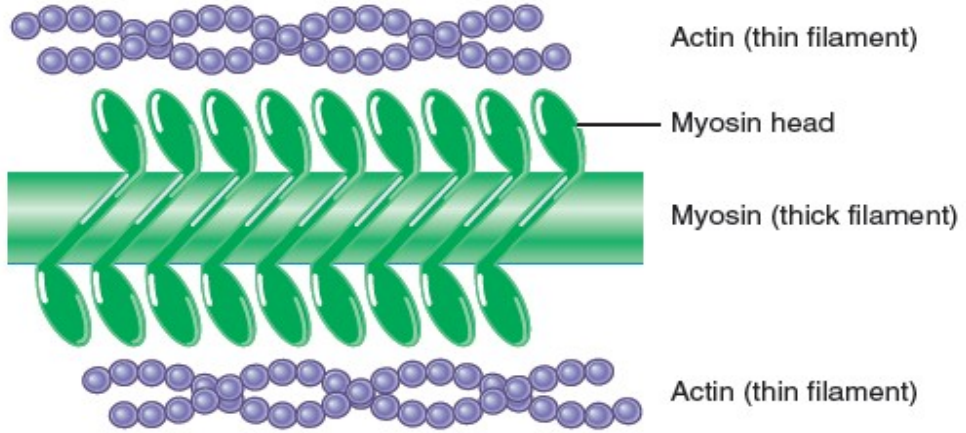
- Depends to a large extent on glycolysis for their metabolic needs

- **Involuntary controlled**

(It receives autonomic nerves that modulate its activity)

Functional Structure of Smooth Musc



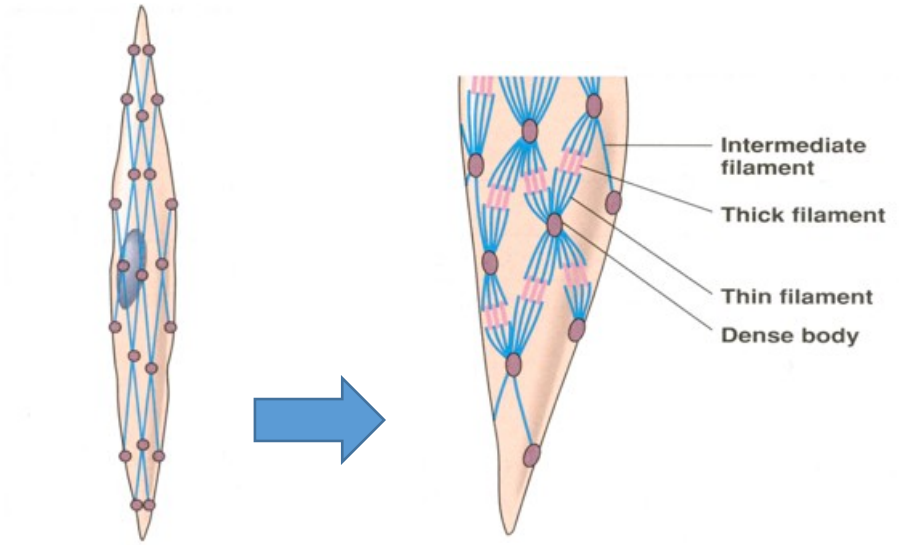


Dense bodies

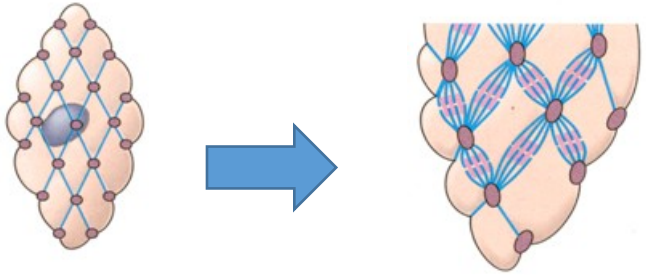
- ✓ **Some are attached to cell membrane**
- ✓ **Others are held in place by a structural protein that cross-attach from one dense body to another**
- ✓ **Large number of actin filaments is attached to the dense bodies**

Smooth Muscle Contraction

Relaxed



Contracted

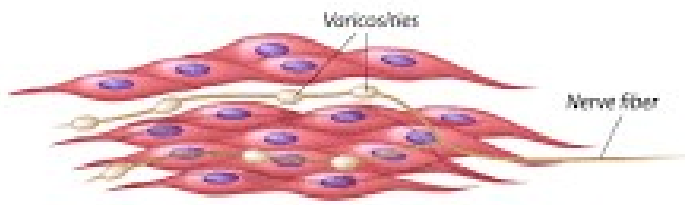


Actin slides on myosin producing tension & shortening

"**Twist**"

Types of Smooth Muscle

Single-unit



Collect into sheets & connected by gap junctions

"**functional syncytium** = syncytial smooth muscle"

Have unstable RMP (*Spontaneous* electrical activity)

"Obeys the all or none law"

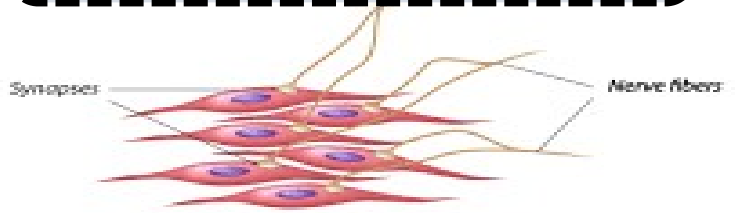
Walls of hollow visceral organs e.g. GIT, UB & uterus

"visceral smooth muscle" = "unitary smooth muscle"

Cells

Site

Multi-unit



Isolated from one another

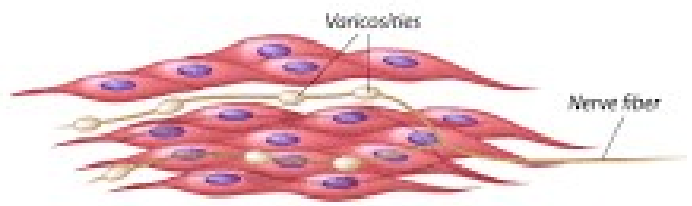
'Does not obey the all or none law"

Have stable RMP & NO spontaneous pacemaker activity

Discrete muscle fibers in ciliary muscle, iris & piloerector muscle

Types of Smooth Muscle

Single-unit



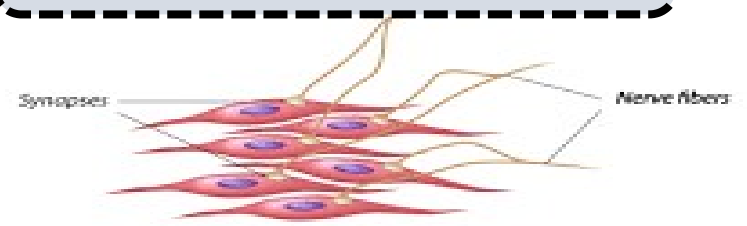
(= **Myogenic**)

- Does not require nervous stimulation for contraction
- Can develop spontaneous contractions

Contract together as a single unit

Contraction

Multi-unit



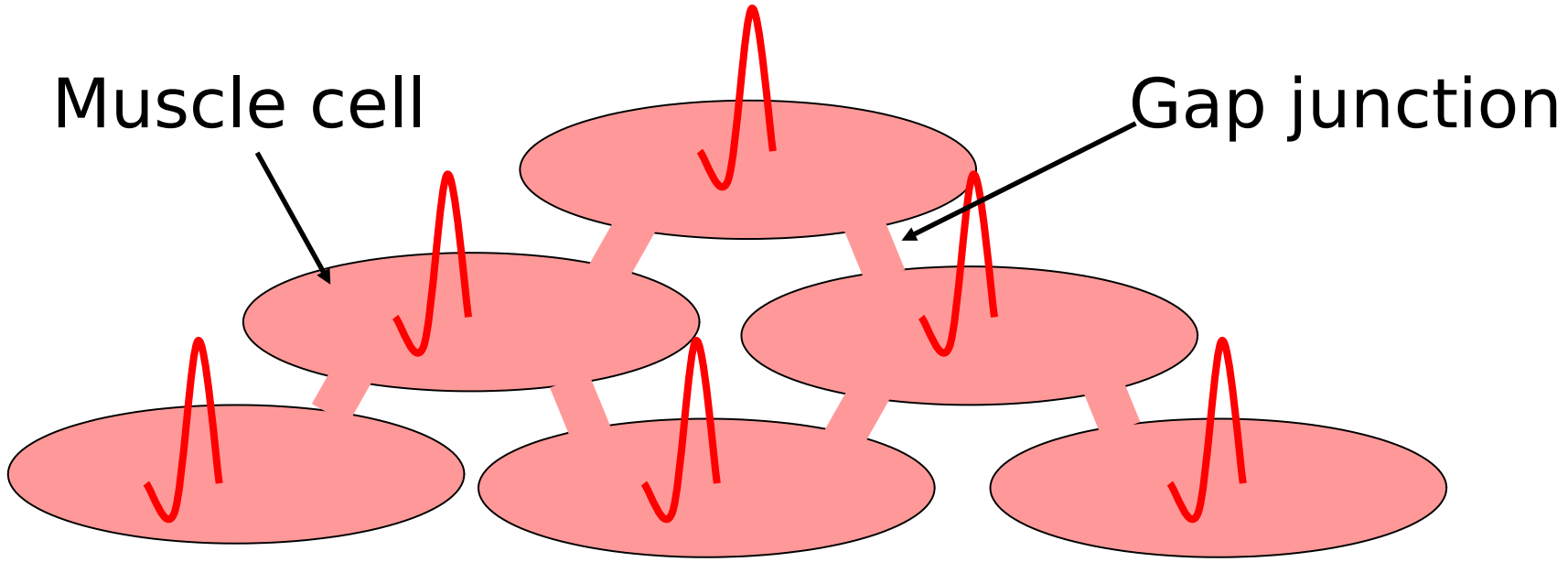
(= **Neurogenic**)

- Dependent on autonomic nerve supply for contraction

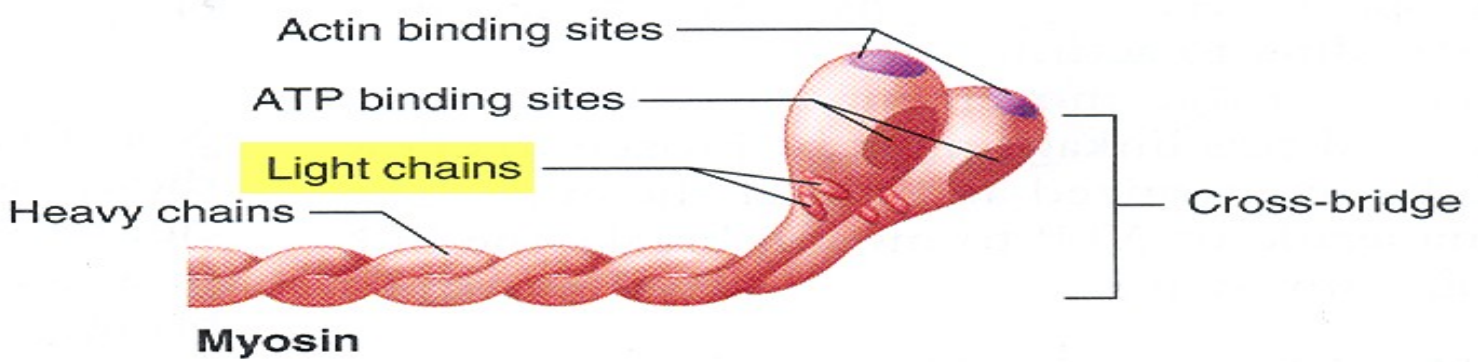
Each fiber contracts independently & separately

Types of Smooth Muscle

Single-unit smooth muscle



Mechanism of Smooth Muscle Contract



Light chains (*attached to myosin heads near the "neck" region*) have a crucial regulatory function in smooth muscle

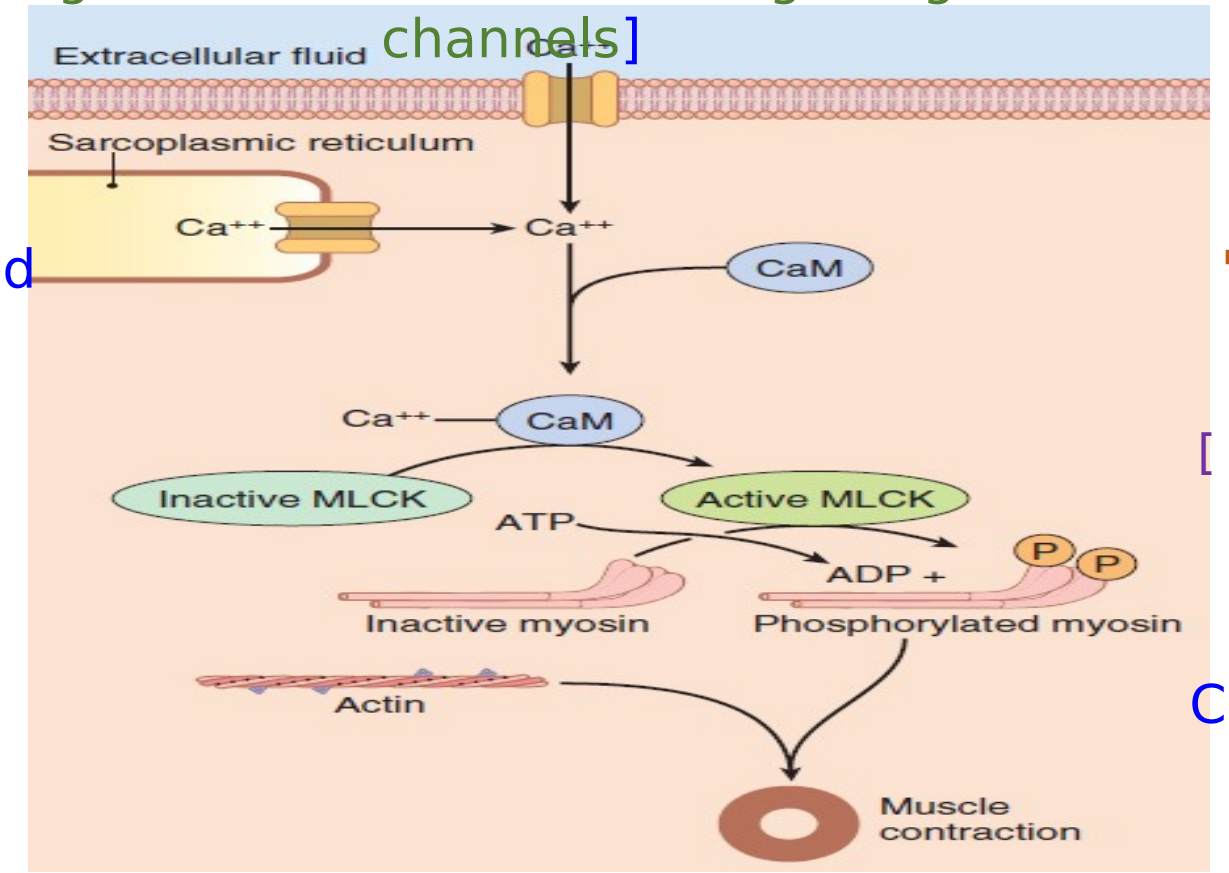
HOW?

Smooth muscle myosin can interact with actin **ONLY** when light chain is **phosphorylated**

Mechanism of Smooth Muscle Contract

Calcium influx into the cytoplasm
(90%) from ECF
[via voltage-gated calcium channel & ligand-gated calcium channels]

Only **(10%)** from the poorly developed SR



Ca^{2+} turns **ON** the cross bridges by inducing a "chemical change" in myosin (Phosphorylation)

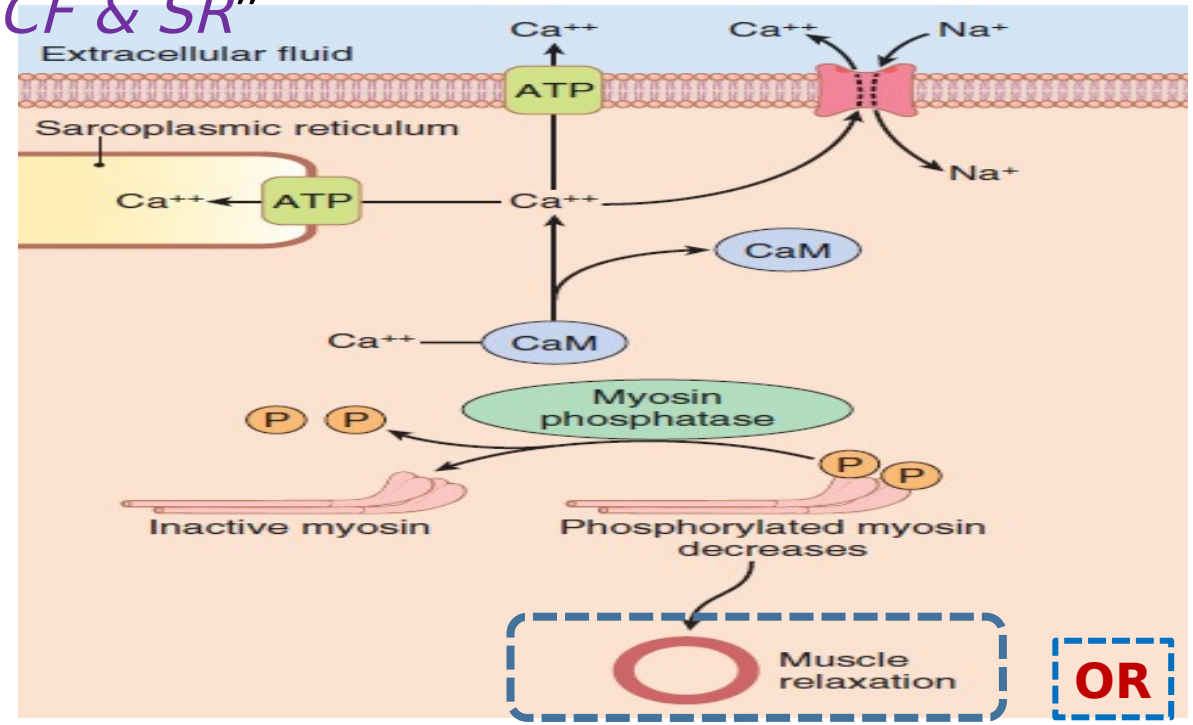
[In skeletal muscle Ca^{2+} induces a "physical change" at the thin filaments]

Cross bridge cycle formation (*Binding & bending & detachment*) but at slower rate

Mechanism of Smooth Muscle Relaxati

Active process

↓ Ca^{2+} level to the resting level "***Pumped*** *to ECF & SR*"



OR

De-phosphrylation of myosin light chain by myosin light chain phosphatase

Sustained contraction "*due to latch bridge mechanism*"

Relaxation occurs when there is final dissociation of calcium– calmodulin complex

Latch Bridge Mechanism

- Mechanism by which myosin cross-bridges remains attached to actin for some time after cytoplasmic Ca^{2+} concentration falls
- This process produces sustained contraction with little energy expenditure

Single-unit

Electric Activity

RMP

- Have unstable RMP (*Spontaneous* electrical activity)

Action potentials

Stimulus

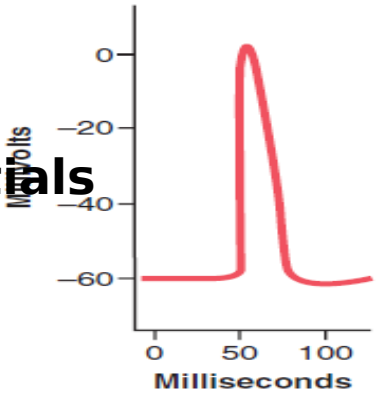
- **Electrical**
- **Hormonal**
- **Self-generated**
- **Neurotransmitters**
- **Stretch**

Mechanism

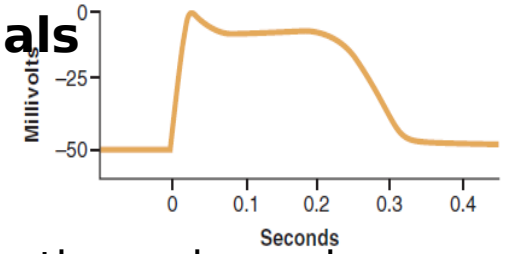
Depolarization: Opening of slow voltage-gated Ca^{++} channels

Re-polarization: Delayed activation of voltage-gated K^{+} channels

1- Spike Potentials



2- Action Potentials with Plateau



Plateau accounts for the prolonged contraction that occurs in some types of smooth muscle e.g. uterus (during labor)

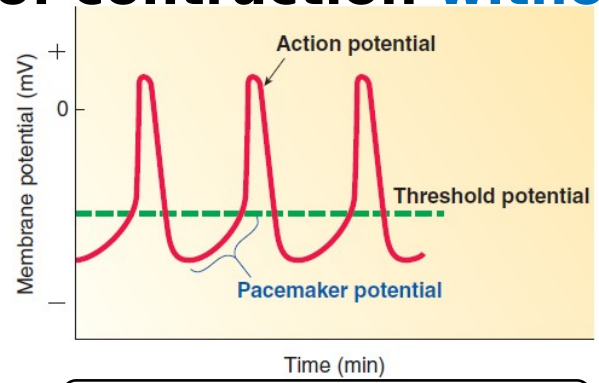
Single-unit

Self-generated Electrical activity

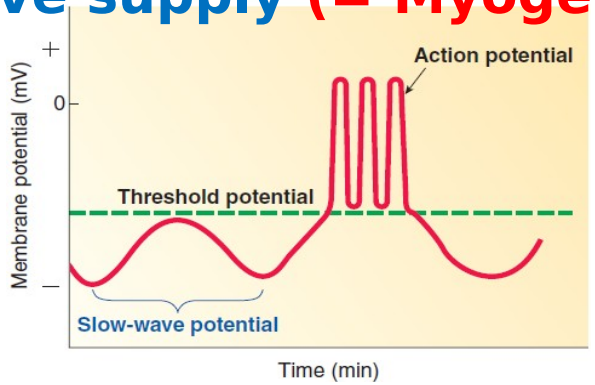
- ✓ **Self-excitable smooth muscle cells are specialized ONLY to initiate action potentials**

(=NOT equipped to contract)

- ✓ **Spontaneous production of APs makes the single-unit smooth muscle cells capable of contraction without need for nerve supply (= Myogenic activity)**



Pacemaker potentials



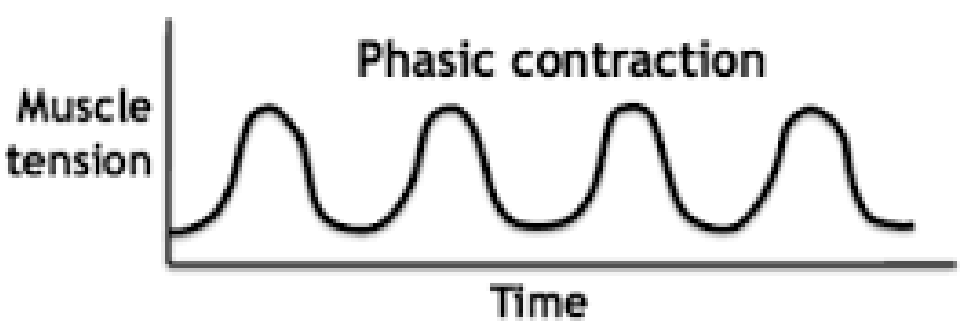
Slow-wave potentials

Sherwood 9th Ed.

Single-unit

Mechanical Activity

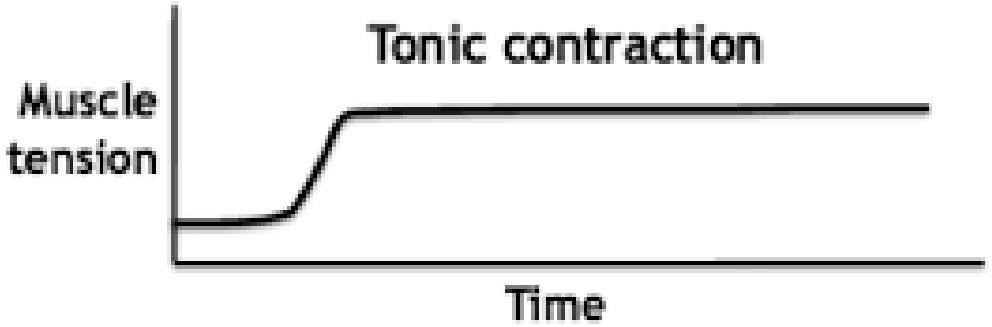
Phasic contraction



= Rhythmic contractions and relaxations

(This type of movement allows propulsion of the lumen content in one direction)

Tonic contraction



= Maintained state of partial contraction

(It is best seen in sphincters of the gut & urinary bladder and in the tone of the blood vessels)

Multi-unit

Electric Activity

✓ **RMP is Stable**

NO spontaneous pacemaker activity

"=No self-generated activity"

Mechanical Activity

✓ **Only phasic**

when stimulated by nerves

Functional Characteristics of Smooth Muscle

Low & Slow ATPase activity

- Slow onset of contraction & relaxation
- Slow cross bridge cycling
- Latch bridge mechanism
  - Prolonged tonic contraction with very little use of energy
- Utilization of small amount of energy
  - Smooth muscle is fatigue resistant

Length–Tension Relat Placticity

(*Variability of the tension it exerts at any given length*)

- Allows hollow viscera e.g. urinary bladder to accommodate ↑amount of urine without much ↑in wall tension

Functional Characteristics of Smooth Muscle

Control of Contraction

Smooth muscle is highly sensitive & adapted to respond to various changes in the internal environment

a) Autonomic NS

b) Hormones (Catecholamines, Vasopressin, Estrogen, Progesterone**)**

c) Chemical Factors: (Ions, pH, Osmotic Pressure, Gases**)**

d) Physical Factors: (Temperature, Stretch**)**

Lecture Quiz

Q- Which of the following is NOT a characteristic of smooth muscles?

A. They contain self-excitable cells

B. They can enter a latch-bridge state

C. They are able to tonically contract

D. Myosin phosphatase is required for contraction

E. The poorly developed sarcoplasmic reticulum

SUGGESTED TEXTBOOKS

1. **Guyton and Hall.** *Text book of Medical Physiology, 13th Edition*
2. **Ganong's** *Review of Medical Physiology, 25th Edition*
3. **Sherwood.** *Human Physiology From Cells to*


Thank You!